SOUTHWEST RESEARCH INSTITUTE®

# Spacecraft Impact Testing and Hazards Analysis

Southwest Research Institute® (SwRI®) supports the government and the commercial space industry with a variety of testing and analysis capabilities. Under NASA sponsorship, SwRI developed the Inhibited Shaped Charge Launcher (ISCL), a unique facility that launches aluminum projectiles and simulates orbital debris impact conditions on the Space Station.

Finite element, computational fluid dynamics (CFD) and hydrocode computer codes are used to simulate a range of problems from low-velocity through hypervelocity impacts, vehicle and crew survivability, and explosion consequences for design and analysis purposes. Fracture analysis of pressurized modules is conducted and supplemented by high strain rate materials testing. SwRI is internationally recognized for experimental and analytical impact studies against the Space Shuttle's thermal protection systems and wing leading edge.

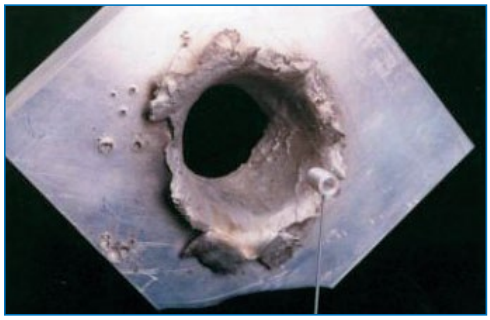
CFD codes are used to simulate fuel release and mixing under failure (on-pad and in-flight) scenarios. Hydrocodes are used to simulate detonation of fuel plumes, resulting over-pressure, and fragment formation in support of crew escape studies.

## Capabilities

- Ballistics and explosives testing
- Materials testing, including high strain rate testing
- High-speed digital video of impacts up to 200,000,000 frames per second
- High-speed data acquisition up to 200 MHz
- ISO-compliant quality assurance
- Computer simulation of impact and structural response
- Explosion consequence analysis
- Crew survivability
- Launch vehicle design assessment

## Experience

- NASA Space Station orbital debris shield impact testing
- Hypervelocity impacts on a wide variety of space components and materials
- Simulated hailstone impacts on Space Shuttle thermal protection tiles
- External tank foam impacts on Space Shuttle components including thermal protection tiles, reinforced carbon-carbon (RCC) panels on the wing leading edge, nose cone and carrier panels
- Scale modeling analyses of ballistic missile defense impact scenarios
- Hypervelocity impact modeling of spacecraft shields and lightweight armors
- Development of velocity scaling concepts for DOD and NASA to extrapolate design curves
- Characterization of impact damage to Space Shuttle windows
- Detailed damage assessments
- Development of damage maps
- Orbital Space Shuttle explosive hazard environment
- Constellation Ares vehicle assessment
- 2nd-generation shuttle launch vehicle assessment
- Atlas V explosion hazard assessment
- In-orbit thermal protection system repair assessment



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*Simulated ISCL projectile (hollow cylinder positioned on rod) and the resulting damage to a 38-mm-thick plate of 3003 aluminum*

D013857

*Foam impact test on Space Shuttle wing*


## KEYWORDS

Spacecraft Shielding

Orbital Debris

Micrometeoroids

Hypervelocity Impact

NASA Impact Testing

Inhibited Shaped Charge Launcher

Explosive Launcher

Thermal Protection Tiles

Shuttle Tiles

Bumper Shields

Velocity Scaling

Ballistic Missile Defense

Foam Impact

Crew Escape Analysis

Explosion Environment

Safety Assessment

## *Facilities*

- Ballistics and explosives test ranges
- Materials test laboratories
- Inhibited shaped charge launcher facility, 0.3 to 1.5 grams of aluminum to 11+ km/s
- Portable instrumentation trailer
- Digital flash X-ray systems with film processing capability
- Machine shops and fabrication facilities
- Compressed gas gun systems for low-velocity impact (hailstones, foam, etc.)
- HPC computer clusters

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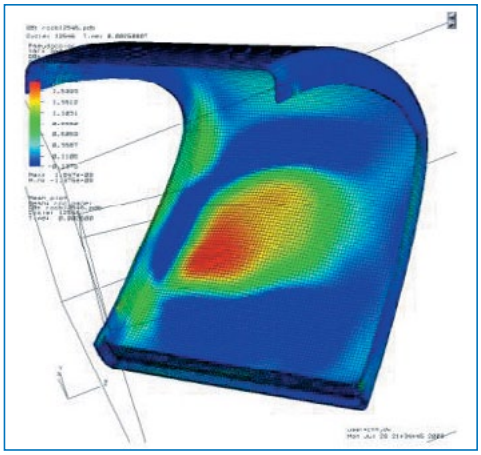
*ISCL facility during a test*



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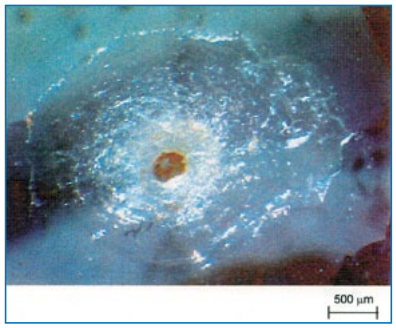
*Computer simulation of foam impact on RCC panel leading edge*




D013853

*Typical hypervelocity impact crater in a Space Shuttle windshield panel, showing central crater and circumferentially located microcrack ensembles*


D013859

*Space Shuttle tile impacted with a piece of insulation material from the external tank*

*Southwest Research Institute is an independent, nonprofit, applied engineering and physical sciences research and development organization using multidisciplinary approaches to problem solving. The Institute occupies 1,200 acres in San Antonio, Texas, and provides more than 2 million square feet of laboratories, test facilities, workshops and offices for more than 3,000 employees who perform contract work for industry and government clients.*

**We welcome your inquiries.**

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